ROYAL ASTRONOMICAL SOCIETY.

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G. B. AIRY, Esq., Astronomer Royal, V.P., in the Chair.

Capt. Arthur Cumming, R.N., Norfolk Street, Park Lane;
Dr. R. W. Eve, High Street, Deptford, Kent;
Rev. C. Evans, Rugby, Warwickshire,

were balloted for and duly elected Fellows of the Society.

Volume XXVI. of the *Memoirs* has recently been published. The price is 6*s.* to the Fellows of the Society, and 12*s.* to the Public. Volume XVII. of the *Monthly Notices*, containing the shorter papers, abstracts of Memoirs, and Notices of New Publications, is given to the purchasers of the 4to. volume. The two publications are supplementary to each other, and are to be considered as parts of the same series. Between them they contain a complete account of the proceedings of the Society during the year.

The publication of the forty-eighth volume of the *Astronomische Nachrichten* has recently commenced. Fellows of the Society desiring to become subscribers are requested to send a notification to that effect to Mr. Williams, the Assistant Secretary of the Society, who will receive the subscription, which is *payable in advance*. This periodical is published in successive numbers, which form two volumes in the course of about a year. The price of each volume is 15*s.* Each number is delivered in England free of any charge for postage.

New Comet.

(*Extract of a Letter from M. Argelander to the Astronomer Royal.*)

"I have the honour to inform you of the discovery of a comet last night by Dr. Winnecke. Its approximate position by the chart was

	R.A.	Decl.
March 8, 14^h M.T.	$258^\circ\ 44'$	$-1^\circ\ 57'$

"Observations with the ring-micrometer, which are not yet completely reduced, give the following position:

	R.A.	Decl.
March 8, $15^h\ 58^m$ M.T.	$258^\circ\ 55'$	$-1^\circ\ 55'$

and the daily motion in right ascension + 108′, in declination 0.

"The comet is a faint nebulous object about 2′ or 3′ in diameter, and without any trace of a nucleus.

"*Bonn, March* 9, 1858."

A circular containing the announcement of the foregoing discovery was forwarded to the observers throughout the country, along with the Annual Report.

Elements of Comet 1, 1858. By M. Pape and M. Bruhns.

(*Communicated by Dr. Lee.*)

The following elements are contained in a letter from our valued associate Dr. Peters to Dr. Lee:—

	Elements of M. Bruhns.	*Elements of M. Pape.*
Epoch 1858, Jan. 22·0 M.T. Berlin.		Feb. 8·0 M.T. Berlin.
	° ′ ″	° ′ ″
M	357 50 43·5	1 3 37·5
ϖ	115 29 4·0	115 40 37·2
Ω	268 54 51·5	268 56 14·8
i	54 32 22·3	54 25 48·1
φ	56 3 33·0	55 42 20·0
Log a	0·780322	0·770987
Revolution	14^y·810	14^y·3377

5 revolutions since Messier's observations of the comet in 1790, give 13^y·6, 4 revolutions, 16^y·5. Hence 5 revolutions appear to be very probable.

Altona, Feb. 19, 1858.

Ephemeris of the Variable Stars for the Year 1858.

By Norman Pogson, Esq.

(Communicated by J. Gurney Barclay, Esq.)

Star.	Probable Mag.	Mean place in 1860. R.A. h m s	N.P.D. ° ′	Dates of Maxima, unless otherwise expressed.	Authority.
T Piscium	9·5	0 24 46	76 14	Middle of May, and early in October.	S
α Cassiopeiæ ..	2·0	0 32 35	34 14	Feb. 7, April 27, July 15, Oct. 2, and Dec. 20.	A
S Piscium	9·0	1 10 15	81 48	March 12.	—
R Piscium	7·5	1 23 25	87 50	Early in June, or about the middle of August.	—
o Ceti	2·0	2 12 17	93 37	November 2.	A
R Tauri	8·0	4 20 38	80 9	October 19.	W
S Tauri	10·0	4 21 33	80 22	January.	—
R Orionis	9·0	4 51 22	82 5	May 1.	W
s Aurigæ.....	3·5	4 51 56	46 23	Possibly early in June, but uncertain.	—
α Orionis	1·0	5 47 36	82 37	April and October.	—
R Geminorum .	7·3	6 58 56	67 5	December 30. Orange.	P
R Canis Minoris	8·0	7 1 0	79 45	Middle of April.	—
S Canis Minoris	8·5	7 25 7	81 23	October 11.	S
S Geminorum..	9·2	7 34 38	66 14	August 5.	P
T Geminorum..	8·9	7 40 54	65 55	June 2.	P
U Geminorum .	9·1	7 46 48	67 38	Jan. 26, May 2, Aug. 7, and Nov. 11. Irregular.	P
R Cancri.....	6·0	8 8 57	77 53	March 10.	A
U Cancri.....	10·0	8 27 45	70 37	Possibly about the end of May.	—
S Hydræ.....	8·5	8 46 15	86 24	July 17.	S
T Hydræ.....	6·5	8 48 51	98 37	Middle of May.	—
R Leonis.	5·0	9 40 2	77 55	April 30; deep red. Min. (10·0). Oct. 4.	P
R Ursæ Majoris	7·0	10 34 41	20 29	March 10. Min. (13·1). September 17.	P
R Comæ.....	8·0	11 57 4	70 26	Early in November.	A
R Virginis	6·5	12 31 24	82 14	Jan. 9, June 4, and Oct. 26.	P
S Ursæ Majoris	7·9	12 37 48	28 8	July 10; dull red. Min. (12·1). April 6, and Nov. 14.	—
U Virginis	7·8	12 44 0	83 41	Possibly about the end of May.	—
R Hydræ	4·0	13 22 5	112 33	Middle of June. Very irregular.	A
S Virginis	6·7	13 25 42	96 28	April 8; fine red, but also variable in colour.	P
S Serpentis....	8·0	15 15 8	75 11	April 7.	A
R Coronæ	6·0	15 42 49	61 25	Middle of November. Irregular.	—
R Serpentis ..	6·5	15 44 15	74 26	September 23.	A
R Scorpii	9·0	16 9 10	112 22	Possibly in the middle of December; but very doubtful.	—
S Scorpii	9·0	16 9 14	112 19	Possibly in April; but very uncertain.	—
S Ophiuchi....	9·5	16 26 12	106 53	February 9, and September 26.	P
R Ophiuchi....	7·6	16 59 44	105 54	May 13.	P

Star.	Probable Mag.	Mean place in 1860. R.A.	N.P.D.	Dates of Maxima, unless otherwise expressed.	Authority.
		h m s	° ′		
α Herculis	3·0	17 8 16	75 27	Jan. 5, March 12, May 18, July 23, Sept. 17, and Nov. 23.	A
R Scuti	5·0	18 40 1	95 50	Feb. 3, April 16, June 26, September 6, and November 17.	A
13 Lyræ	4·3	18 51 4	46 14	Jan. 13, Feb. 28, April 16, June 1, July 17, Sept. 2, Oct. 18, and Dec. 4.	B
R Aquilæ	6·5	18 59 40	81 59	July 7; fine red.	W
R Cygni	8·0	19 33 4	40 7	April 23; bluish white. Min. (14·3?) Dec. 23.	P
χ Cygni	5·0	19 45 11	57 27	Not until January 29, 1859.	A
T Capricorni ..	9·0	21 14 17	105 45	January 24, and October 25.	S
R Pegasi.....	8·5	22 59 38	80 13	March 8.	A
R Aquarii	7·0	23 37 15	106 3	May 9.	A
R Cassiop. (2nd)	6·5	23 51 18	39 23	February 2; fine bright red.	P

Minima of the Short-period Variable Stars during the year 1858, *in Greenwich Mean Time, and for the Earth's Mean Distance from each Star.*

Algol.
Max. 2·3. Min. 4·0.
Whole variation complete in 7 hours.
(A)

	h m		h m
Jan. 1	12 54	Aug. 27	12 30
4	9 43	30	9 19
7	6 32	Sept. 16	14 12
21	14 36	19	11 1
24	11 25	22	7 50
27	8 14	Oct. 6	15 54
30	5 3	9	12 43
Feb. 13	13 7	12	9 32
16	9 56	15	6 21
19	6 45	26	17 36
Mar. 5	14 49	29	14 25
8	11 38	Nov. 1	11 14
11	8 27	4	8 3
31	10 9	18	16 7
Apl. 3	6 58	21	12 56
23	8 40	24	9 45
May 13	10 22	27	6 34
June 5	8 53	Dec. 8	17 49
22	13 46	11	14 38
July 15	12 17	14	11 27
Aug. 4	13 59	17	8 16
7	10 48	20	5 5
24	15 41	31	16 20

λ Tauri.
Max. 4·0. Min. 4·5.
Variation rapid.
(B)

	h m
Jan. 2	15 11
6	14 4
10	12 59
14	11 48
18	10 40
22	9 32
26	8 25
30	7 17
Feb. 3	6 9
Sep. 8	16 0
12	14 52
16	13 44
20	12 36
24	11 28
28	10 21
Oct. 2	9 13
Nov 26	17 24
30	16 16
Dec. 4	15 8
8	14 0
12	12 52
16	11 45
20	10 37
24	9 29
28	8 21

δ Cephei.
Max. 3·7. Min. 4·8.
Increasing 1^d 14^h·4
(A)

	h m
Jan. 15	12 5
26	5 40
30	14 28
Feb. 11	8 3
27	10 26
Mar. 15	12 49
31	15 12
Apl. 11	8 48
27	11 11
May 13	13 34
June 9	9 32
25	11 55
July 11	14 18
Aug. 7	10 16
23	12 39
Sep. 8	15 2
19	8 38
Oct. 5	11 1
21	13 24
Nov. 1	6 59
6	15 47
17	9 22
Dec. 3	11 45
14	5 20
19	14 8
30	7 43

η Aquilæ.
Max. 3·6 Min. 4·4.
Increasing 2^d 9^h
(A)

	h m
Feb. 14	18 15
Mar. 22	15 25
Apl. 27	12 35
June 9	14 0
July 15	11 10
22	15 24
Aug. 20	8 20
27	12 34
Oct. 2	9 45
Nov. 7	6 55
Dec. 13	4 5

ζ Geminorum.
Max. 3·8. Min. 4·5.
Increasing 5^d 6^h
(A)

	h m
Jan. 8	12 36
18	16 24
Feb. 28	7 36
Mar. 10	11 24
20	15 12
May 10	10 12
Sep. 29	15 24
Nov. 19	10 24
29	14 12
Dec. 9	18 0

S Cancri.
R.A. $8^h\ 35^m\ 56^s$
N.P.D. 70° 28′
Max. 8·0. Min. 10·5.
Variation rapid.
(A)

	h	m		h	m
Jan. 2	6	43	Mar. 9	16	1
11	18	7	Nov. 20	17	38
21	5	56	Dec. 9	16	52
30	17	33	28	16	5
Feb. 18	16	47			

β Lyræ.
Minimum 4·3.
(A)

First Max. (3·4) about $3^d\ 2^h$ after Minimum.
Second Min. (3·8) about $6^d\ 9^h$ after Minimum.
Second Max. (3·4) about $9^d\ 10^h$ after Minimum.

	h	m
Jan. 7	15	29
May 29	14	46
June 11	12	32
24	10	17
Oct. 31	11	49
Nov. 13	9	34
26	7	19
Dec. 9	5	4

The corrections to be applied to the observed times of minima of the short-period variables, before comparing with the ephemeris, may be found by the formulæ on page 27 of vol. xvii. of the *Monthly Notices*.

R *Leporis* (Hind's crimson star), T *Cancri*, and *Hydræ*, T and 21 *Virginis*, R and S *Herculis*, R *Capricorni*, S and β *Pegasi*, μ *Cephei* (Sir W. Herschel's garnet star), and S *Aquarii*, all stars of well-established variability, have been reluctantly omitted from the preceding list for want of trustworthy elements by which to compute their maxima. The initials in the last column indicate the authority upon whose numbers the predicted times depend, and stand for Argelander, Baxendell, Pogson, Schoenfeld, and Winnecke, respectively.

My acknowledgments are especially due to Prof. Argelander for his valuable corrections of my last year's ephemeris (*Monthly Notices*, vol. xvii. page 149); to the able papers of Drs. Schoenfeld and Winnecke (*Ast. Nach.* 1099 and 1120); to my excellent friend, Josh. Baxendell, Esq., who contributed the times for his two variables λ *Tauri* and 13 *Lyræ;* and, lastly, to Mons. Chacornac, who obligingly supplied me with such information as will, I trust, lead to a better determination of the periods of two of his interesting discoveries, viz. R and S *Scorpii*. This pair of variables is in the same field of view with, and north-following a nebula or cluster, which lies midway between two stars of the 7th magnitude. Their maxima will, it is to be feared, occur at very unfavourable times during the present year; but as the periods are little better than mere guesses, they much need further watching. For twelve of the stars, which I have elsewhere adopted as my special charge, the elements obtained from a discussion of my own observations have been employed, and will not prove much in error. U *Geminorum*, however, appears to be decidedly irregular; also R *Leonis* and S *Virginis*. The first of these is even now invisible, though considerably behind the computed time.

In M. l'Abbé Moigno's *Cosmos*, vol. viii. page 366, we find 1706 and 8122 B.A.C., announced as variable by M. Ernest Liouville. The latter star is there stated to vary from the 5th to the 10th magnitude, in a period of 115 days. I have for some time watched both, without perceiving any change in either. The first ranks rather below the 6th magnitude. The other, which I have more frequently examined, has always appeared to me of about the 7th magnitude. M. Liouville does not say whether he has *himself* witnessed such a periodical variation. If so, the stars in question belong to the same class as 34 *Cygni*, Mr. Hind's new star in *Ophiuchus*, and others generally steady, but occasionally undergoing change. Until further information has been given, in support of such variation, we may infer that M. Liouville has formed his opinion only from a comparison of the magnitudes assigned to these stars in the various catalogues in which they occur. Now when we consider that during a meridian observation the mind is much more intent upon the determination of place than of magnitude, the difficulty, I may say the *impossibility*, of the most experienced always adhering strictly to the standard scale; the chance of intervening, but unnoticed clouds; of dew on the object-glass; and, above all, the risk of press-errors, the circumstance of a difference existing between the recorded catalogue magnitudes, or even among the estimations of the same observer, is no real proof of invariability. This can only be decided by careful comparisons with neighbouring stars; and until the suspected change has been verified by differential observations, no star can be entitled to take place in a list of "KNOWN VARIABLES."

In a valuable communication respecting χ *Cygni* (*Ast. Nach.* 1045) Prof. Argelander took occasion to direct the attention of astronomers to the difficulty of estimating red stars, and made some interesting remarks, which I and my colleague, Adolph Quirling, can fully corroborate. That some eyes see red light more vividly than others is unquestionably true in our own case.

Thus, when the fine red light of α *Orionis* impresses me as decidedly superior in intensity to the white light of *Rigel*, Mr. Quirling estimates the latter much the brighter. With an opera-glass he makes them more nearly equal, though still giving the preference to *Rigel*. Again, in the case of R *Leporis* (Hind's crimson star), which I have usually recorded as 6·3 or 6·5 mag. Mr. Quirling has on the same nights invariably estimated it at either 7·5 or 7·7 mag. The same differences exist between our estimations of R *Leonis*, R *Aquilæ*, R *Cassiopeiæ*, and other red stars, while those of ordinary, *i.e.* white and yellow stars, agree on the whole pretty closely. But the difficulty does not end here; for a red star, estimated equal, or even slightly inferior to an adjacent white star, with a telescope of small aperture, is decidedly inferior when both are seen through a greater aperture. Hence, in order to deduce the correct time of maximum of a red variable, it is necessary that the increase and decrease should be

watched throughout with the same telescope. Imagination works wonders with the vision of many susceptible persons, and what they expect they really appear to see; but no such explanation can set aside the curious fact above mentioned; and I may add, that both I and my friend view such matters very deliberately before pronouncing an opinion.

As I hope to continue this ephemeris annually, and in future to have it ready before the commencement of each year, I need scarcely mention how acceptable will be the communication of later and corrected elements, especially for the variables now omitted, and for those in the present ephemeris which stand unvouched for by the initial of any responsible authority.

2 *South Parade, Oxford, Feb.* 2, 1858.

Results of the Observations of Small Planets, made at the Royal Observatory, Greenwich, in the months of January and February, 1858.

(*Communicated by the Astronomer Royal.*)

Flora.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ′ ″
1858, Jan. 11 12 7 43·6	7 32 31·55	68 1 49·71
13 11 57 35·3	7 30 14·74	67 48 31·94
14 11 52 30·5	7 29 5·62	67 42 15·13
18 11 32 16·9	7 24 35·00	67 17 43·88
20 11 22 15·3	7 22 24·88	67 6 4·63
21 11 17 16·3	7 21 21·54	67 0 22·63
26 10 52 40·3	7 16 24·28	66 33 40·28
27 10 47 49·8	7 15 29·55	66 28 39·85
28 10 43 0·8	7 14 36·33	66 23 46·52
Feb. 1 10 24 3·1	7 11 21·81	66 5 30·83
4 10 10 10·3	7 9 16·38	65 53 6·06
5 10 5 36·8	7 8 38·70	65 49 13·61
6 10 1 5·5	7 8 3·20	65 45 27·46
8 9 52 9·3	7 6 58·61	65 38 17·04
9 9 47 44·7	7 6 29·81	65 34 54·13
19 9 5 42·2	7 3 46·01	65 7 17·96
20 9 1 42·3	7 3 41·96	65 5 14·65
22 8 53 49·9	7 3 41·41	65 1 11·10
24 8 46 6·2	7 3 49·59	64 57 36·83
25 8 42 17·9	7 3 57·14	64 55 58·67
27 8 34 47·2	7 4 18·36	64 53 0·02

Metis.

Mean Solar Time of Observation.			Apparent R.A.	Apparent N.P.D.
	h m s		h m s	° ′ ″
1858, Jan.	9	9 1 59·1	4 18 23·48	65 51 8·91
	14	8 41 43·9	4 17 47·69	65 42 15·31
	18	8 26 13·4	4 18 0·92	65 34 20·16
	19	8 22 26·8	4 18 10·28	65 32 18·32
	26	7 57 1·4	4 20 16·54	65 16 39·90
	27	7 53 32·2	4 20 43·40	65 14 12·37
	28	7 50 5·0	4 21 12·17	65 11 46·58
Feb.	1	7 36 36·3	4 23 27·46	65 1 49·37
	4	7 26 50·3	4 25 29·48	64 53 50·40
	6	7 20 28·8	4 27 0·10	64 48 29·35
	8	7 14 14·6	4 28 37·94	64 43 1·82
	9	7 11 10·2	4 29 29·60	64 40 16·26
	18	6 44 45·4	4 38 29·50	64 15 2·73
	20	6 39 10·4	4 40 46·68	64 9 24·44
	22	6 33 41·4	4 43 9·88	64 3 49·66
	24	6 28 (19)	... ...	63 58 18·86

Irene.

Mean Solar Time of Observation.			Apparent R.A.	Apparent N.P.D.
	h m s		h m s	° ′ ″
1858, Jan.	9	7 29 18·7	2 45 27·88	79 3 10·35
	11	7 21 44·2	2 45 45·19	78 53 43·92
	14	7 10 33·7	2 46 22·57	78 38 52·66
	19	6 52 25·3	2 47 53·99	78 12 27·71
	28	6 21 15·9	2 52 8·45	77 20 36·84

Themis.

Mean Solar Time of Observation.			Apparent R.A.	Apparent N.P.D.
	h m s		h m s	° ′ ″
1858, Jan.	20	10 56 38·9	6 56 44·20	65 59 49·70
	27	10 23 54·2	6 51 30·06	65 53 50·25
Feb.	4	9 47 42·5	6 46 44·84	65 49 41 13
	18	8 48 16·2	6 42 20·56	65 48 27·06
	19	8 44 14·0	6 42 14·25	65 48 32·86
	27	8 12 55·9	6 42 23·43	65 51 4·87

Eunomia.

Mean Solar Time of Observation.	Apparent R. A.	Apparent N.P.D.
h m s	h m s	° ′ ″
1858, Jan. 21 14 35 0·3	10 39 38·10	91 52 6·52
Feb. 4 13 29 53·0	10 29 31·87	92 4 42·41
5 13 25 6·3	10 28 40·92	92 4 23·11
6 13 20 18·8	10 27 49·15	92 3 49·55
18 12 22 3·9	10 16 43·40	91 46 10·60
19 12 17 11·0	10 15 46·22	91 43 48·20
20 12 12 17·6	10 14 48·64	91 41 22·80
22 12 2 31·8	10 12 54·30	91 36 5·31
24 11 52 46·6	10 11 0·61	91 30 26·96
25 11 47 54·5	10 10 4·26	91 27 26·45
27 11 38 11·2	10 8 12·45	91 21 15·37

Fortuna.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ′ ″
1858, Feb. 4 14 16 48·8	11 16 35·38	87 22 32·49
9 13 53 53·3	11 13 18·91	87 2 22·71
18 13 11 26·9	11 6 14·55	86 17 26·87
19 13 6 39·9	11 5 23·31	86 11 51·24
20 13 1 51·5	11 4 30·66	86 6 19·69
22 12 52 14·1	11 2 44·74	85 54 49·32
24 12 42 34·3	11 0 56·52	85 43 9·85

Amphitrite.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ′ ″
1858, Feb. 24 14 26 57·2	12 45 36·55	95 29 11·33
25 14 22 29·2	12 45 4·31	95 28 16·27

Isis.

Mean Solar Time of Observation.	Apparent R.A.	Apparent N.P.D.
h m s	h m s	° ′ ″
1858, Jan. 4 9 43 39·5	4 40 27·96	68 6 7·45
9 9 20 57·2	4 37 24·71	67 57 49·41

Melpomene.

Mean Solar Time of Observation.			Apparent R.A.		Apparent N.P.D.		
	h	m s	h	m s	°	′	″
1858, Feb. 18	14	35 20·8	12	30 22·16	86	47	16·52
19	14	30 56·1	12	29 53·29	86	39	27·28
22	14	17 32·6	12	28 17·31	86	15	20·18
25	14	3 57·7	12	26 29·84	85	50	8·05

Lutetia.

Mean Solar Time of Observation.			Apparent R.A.		Apparent N.P.D.		
	h	m s	h	m s	°	′	″
1858, Feb. 19	13	26 1·6	11	24 48·14	81	8	55·00
20	13	21 17·5	11	23 59·84	81	3	0·87
22	13	11 47·2	11	22 21·11	80	50	53·43
25	12	57 26·1	11	19 47·29	80	32	34·90

Calliope.

Mean Solar Time of Observation.			Apparent R.A.		Apparent N.P.D.		
	h	m s	h	m s	°	′	″
1858, Jan. 4	9	54 33·6	4	51 23·80	60	31	42·06
9	9	31 39·5	4	48 8·74	60	21	28·81
19	8	48 7·5	4	43 55·12	60	3	57·48
Feb. 4	7	45 5·6	4	43 47·78	59	38	52·22
6	7	37 46·3	4	44 20·48	59	35	46·69
8	7	30 33·9	4	44 59·95	59	32	35·24
19	6	52 56·2	4	50 38·17	59	14	50·02
22	6	43 13·2	4	52 43·23	59	9	53·72

Euterpe.

Mean Solar Time of Observation.			Apparent R.A.		Apparent N.P.D.		
	h	m s	h	m s	°	′	″
1858, Jan. 9	14	45 13·0	10	2 33·78	76	12	57·32
Feb. 4	12	44 34·3	9	44 5·70	74	3	1·19
20	11	26 6·3	9	28 29·75	72	36	57·06
24	11	6 56·7	9	25 3·23	72	19	59·94
25	11	2 12·9	9	24 15·19	72	16	1·28
27	10	52 49·1	9	22 42·95	72	8	46·36

Note on Oltmanns' Calculation of the Eclipse of Thales.

By G. B. Airy, Esq., Astronomer Royal.

In the course of last winter, I learnt from our Secretary, Mr. Carrington, that exception had been taken to remarks which I made in the *Philosophical Transactions*, 1853, page 181, line 4 from the bottom; which remarks were grounded on the assumption that M. Oltmanns had used Bürg's motion of the moon's node *uncorrected* for his calculation of the eclipse adopted by him as that of Thales, namely, the eclipse of −609, September 29, and had used a *corrected* motion of the moon's node for the eclipse of Agathocles; and in which I expressed my astonishment that M. Oltmanns, in insisting on the sufficiency of the corrected motion of the node for the eclipse of Agathocles, had in no way alluded to its concomitant insufficiency for connexion of the eclipse of −609, September 29, with the eclipse of Thales, and to the consequent error of his former deductions. And the ground taken for the exception was, that M. Oltmanns, in his paper in the *Berlin Memoirs*, 1812–1813, page 78, line 14, has expressly stated that Bouvard's correction of 2′ to the secular motion of the node (the same adopted in the calculations of the eclipse of Agathocles) had been employed in the calculations of the eclipse of Thales.

An excessive pressure of employments during the spring of this year has prevented me from looking to this matter till the present time. I have now, however, sufficiently examined it to be able to lay before the Society a correct statement of the facts; and I trust that this question will now be finally set at rest.

In reading M. Oltmanns' paper, it is impossible to avoid being struck with the impression that his principal object was to controvert Volney's supposition that the eclipse of − 625, February 2 (astronomical), was the eclipse of Thales. It appears that this had become a party question among the *savans* of Paris. This circumstance may tend to explain the difference in the treatment of this eclipse, and the expressions applying to this eclipse, from those used in reference to the other eclipses of his paper.

The point in question, it will be remarked, is the value of the secular motion used for the moon's node. I will copy out the exact words used by M. Oltmanns for the different eclipses.

Eclipse of − 625, *February* 2.

"Hiefür finde ich, nach den neuesten Sonnen- und meinen vor 5 Jahren bekannt gemachten Mondstafeln, folgende Elemente, wobei, auf Delambre's Ersuchen, Bouvard's Aenderung der 100-jährigen Mondknoten-Bewegung berücksichtigt wurde."

Eclipse of − 584, *May* 28.

"Ich fand, nach den neuesten Sonnen- und meinen eigenen Mondtafeln, folgende Resultate."

Eclipse of — 602, *May* 17.

"Meine neuen Tafeln."

Eclipse of —609, *September* 29.

"Wir berechneten nach unseren neuesten Sonnen- und Monds-Tafeln folgende geocentrische Stücke."

It will be remarked here that Bouvard's correction of the node is *mentioned* only in connexion with the eclipse of — 625; and this singularity gives rise to the suspicion that Bouvard's correction has not been *used* in connexion with the other eclipses; and especially, that it has not been used in connexion with the eclipse of — 609. I will now demonstrate the certainty of this suspicion. My method of demonstration will be the following:

It is known that Mr. Baily's calculations (*Phil. Trans.* 1811, page 220, &c) were made by the use of Bürg's Lunar Tables, without any correction whatever. It is known also that Mr. Baily never was engaged in the investigation of corrections to the lunar elements, and that no confusion can therefore have arisen from the accidental introduction or omission of corrections of the motion of node. Mr. Baily's results may therefore be accepted without scruple as those obtained by a good computer by the pure application of Bürg's Tables.

It is known also that Oltmanns' Lunar Tables, to which M. Oltmanns refers in all his accounts of eclipse-calculations (and which are printed in the 4th supplement to the *Berliner Jahrbuch*, page 1, &c.), were intended to represent exactly the same theory (namely Laplace's) which Bürg's were intended to represent. Also it may be seen that the epochs and movements of the moon's node, as far as they go, are identical with those of Bürg, (it being remarked that with one the day begins at noon, and with the other at midnight; and that there is a small difference in the mode of numerating the days).

The calculations of Baily and Oltmanns are therefore founded essentially on the same basis, as regards the motions of the moon; and ought to give places for the moon not differing more than a few seconds, unless Bouvard's, or some correction, has been applied to the motion of the node.

In the exhibition of the circumstances of the eclipses, the elements of the Solar Tables will enter. I cannot answer in the same way for the identity of these; but this is unimportant, for the following reason. Each of these computers has exhibited for his own time of true conjunction, the moon's true longitude and true latitude. The difference between the two longitudes is small; the corresponding change of latitude is easily computed; and thus I am able to exhibit the latitudes of the two computers for one given longitude; and to compare the two latitudes, and thus to compare the places of node, with the utmost severity.

The only further condition required is the statement whether

the eclipse occurred at an ascending or descending node ; which determines the sign of the factor of the difference of longitudes. The magnitude of the factor may be taken $\frac{1}{10}$ without great error.

I now exhibit the Table of Comparison :

Year of Eclipse.	Node.	Baily's		Oltmanns'			Excess of Oltmanns' reduced Latitude over Baily's.
		Longitude at Conjunction.	North Latitude at Conjunction.	Longitude at Conjunction.	North Latitude at Conjunction.	Latitude reduced to Baily's Longitude.	
		s o ′ ″	′ ″	s o ′ ″	′ ″	′ ″	′ ″
−625	D	10 7 47 47	44 28	10 7 46 17	40 33·8	40 24·8	−4 3
−584	A	1 29 41 4	12 39	1 29 41 26	12 35·5	12 33·3	−0 6
−602	A	1 19 15 44	17 15	1 19 13 39	17 1·4	17 13·9	−0 1
−609	A	5 29 59 40	29 57	6 0 1 8	30 9·8	30 1·0	+0 4

Computing from the numbers in the last column the excess of Oltmanns' longitude of node above Baily's or Bürg's longitude of node, (which will have in the eclipse of −625 the same sign as that of the excess of Oltmanns' north latitude, and in the other eclipses the sign opposite to that of the excess of Oltmanns' north latitude), by means of the factor $\frac{37' 24''·3}{3' 26''·5}$, which is the proportion of hourly motions in longitude and latitude, for the first or large number, and by the factor 10 for the smaller numbers ; we have the following table :—

Excess of Oltmanns' adopted Longitude of Node above Bürg's Longitude of Node.

Year of Eclipse.	Excess of Oltmanns' Longitude of Node.
	′ ″
−625	−44 0
−584	+ 1 0
−602	+ 0 10
−609	− 0 40

The correction to the secular regression, of −2′ for a century, found by Bouvard in the *Monatliche Correspondenz*, 1811, and cited by Oltmanns in the *Berliner Jahrbuch*, 1824, applied backwards for 24 centuries would produce −48′ 0″. Whatever may be the origin of the small difference between 44′ 0″ and 48′ 0″ for −625, and of the small quantities in the other years, it is perfectly clear that my surmise, founded upon M. Oltmanns' language, was correct ; that Bouvard's correction of movement of node, or one very nearly equivalent to it, was applied, as Oltmanns states, in the calculations for the eclipse of −625 ; but that no such correction was applied in the calculations for the other

eclipses; and, specially, that no such correction was applied in the calculations for the eclipse of −609 now under consideration.

Collateral proofs to the same effect are the following:—

(1.) The path of the shadow for −609, computed by M. Oltmanns, agrees with that computed by Mr. Baily as closely as the calculations of two computers usually agree; and the fundamental elements of their Lunar Tables must therefore have been the same. Mr. Baily's movement of the node was certainly Bürg's, without correction; therefore M. Oltmanns' movement of the node was Bürg's, without correction.

(2.) The periodical terms of Bürg's and of Hansen's Tables differ by quantities which, in reference to the discordance now under consideration, are inconsiderable; and Hansen's motion of the node does not differ much from Bürg's motion with Bouvard's correction; as will appear from the circumstance that the path of the shadow in the eclipse of Agathocles given by me from Hansen's Tables in the *Memoirs* of this Society, agrees sufficiently with that given by Oltmanns from Bürg's motion with Bouvard's correction in the *Berliner Jahrbuch*, 1824. A calculation of the eclipse of −609 with Bürg's Table and Bouvard's correction, would therefore give nearly the same path as a calculation from Hansen's Tables. Some time ago Professor Hansen kindly furnished me with the following places:—

Greenwich M. T. −609 Sept.	Moon's R.A.	Moon's N. Dec.	Moon's Equat. Hor. Par.	Sun's Mean R.A.	Sun's App. R.A.	Sun's N. Dec.	Sun's Lg. Rad. Vector.
d	° ′ ″	° ′ ″	′ ″	° ′ ″	° ′ ″	° ′ ″	
29·718	178 40 31·5	1 3 43·1	60 50·47		179 45 56·3	0 6 11·6	
29·768	179 23 14·4	0 49 26·9					
29·818	180 5 55·3	0 35 8·8	60 48·43	181 33 54·9	179 51 27·2	0 3 45·9	9·999589
29·868	180 48 34·8	0 20 51·8					
29·918	181 31 12·5	0 6 35·1	60 46·23		179 56 57·9	0 1 20·2	

and from these, at my request, Mr. Breen computed the following ordinates of the central path of the shadow:—

Central Path of the Eclipse of −609, *Sept.* 29, *from Hansen's Tables.*

E. Longitude.	N. Latitude.	E. Longitude.	N. Latitude.
° ′	° ′	° ′	° ′
23 2	51 21	34 20	49 34
26 26	50 54	36 30	49 8
29 22	50 27	38 29	48 42
31 59	50 1	40 20	48 17

and this is nearly the path which M. Oltmanns would have found if he had applied Bouvard's correction to Bürg's motions. The shadow passed nearly in a great circle; from a point a little way south of Berlin, keeping its course nearly two degrees north of the Sea of Azov, and to a point a few miles south of Astrakhan.

The eclipse of −609 is now, it is hoped, dismissed for ever from any consideration in reference to a supposed connexion with the eclipse of Thales.

On reviewing these numbers, it will be seen that the remarks which I made in the *Phil. Trans.*, 1853, are supported in all their integrity. To prevent all mistake, I quote the words here:—

"M. Oltmanns, ... using his own tables (equivalent to Bürg's), exhibits the detailed elements of several eclipses, and finds that the eclipse of B.C. 610, Sept. 30, was total on the Halys and at Erzeroum (a result agreeing precisely with Mr. Baily's)."

"M. Oltmanns remarks that the close agreement between Mr. Baily's results and his own on the eclipse of Thales, proves the correctness of their calculations;* and then he proceeds to say, that the researches of Bouvard, Burckhardt, and Wurm, as well as his own, show that the secular regression of the node must be diminished 2′ (or reduced to 134° 9′ 42″); that with this the eclipse was possible, supposing Agathocles near Cape Passaro; that to make the eclipse central there, the regression must be further diminished (as I understand him) by 18″, and to make it barely possible it must be increased by 9″. But after insisting on the certainty of this correction of the node, and after having called attention to his former calculations on the eclipse of Thales, he never so much as hints that his former conclusions must now necessarily be erroneous. I am wholly unable to account for this extraordinary silence."

Nor can I account for it now. The most charitable conjecture that I can form is, that M. Oltmanns, as soon as he was fully possessed of Laplace's Theory, and had formed his own tables, computed the eclipses of −584, −597, −608, −609, and laid his calculations aside; that investigations for the correction of motion of node were then made; that the rising importance of the party question on the eclipse of −625 induced him to compute it with the best modern appliances; and that he then withdrew his former calculations from their place of preservation, and attached them to the new ones (how the correction of node-motion was omitted, I cannot conceive); and that finally, in the year 1821, he had forgotten all these particulars. But, whatever the cause may have been, it has produced the same effect as a wilful perversion.

* The original is "Könnte wenigstens ein günstiges Vorurtheil für die Richtigkeit unserer Zeitangabe erwecken," "might at least create an impression in favour of the accuracy of our date of the eclipse." The sense is the same, for my purpose.

The title of M. Oltmanns' paper gives some presumption that he was inaccurate in his habits of scientific thought:—"Uber die wahre Epoche der grossen von Herodot erwähnten Sonnenfinsterniss am Flusse Halys." Herodotus does not say a word about the river Halys; and there is no reason whatever for connecting the battle with the river Halys.

It is pointed out to me, through Mr. Carrington, that the value which I have assigned to the daily motion of the node is incorrect. It is so. The correct value, $3'\ 10''{\cdot}6$, is used in my private papers: the accurate value is $3'\ 10''{\cdot}64$; and apparently the cypher has been lost in transcription.

Before dismissing this subject, I will allude to one point upon which much discussion has been founded, namely, the asserted prediction of the eclipse by Thales. I think it not at all improbable that the eclipse was so predicted; and there is one easy way, and only one, of predicting it—namely, by the *Saros*, or period of 18 years 10 days 8 hours nearly. By use of this period, an evening eclipse may be predicted from a morning eclipse; but a morning eclipse can rarely be predicted from an evening eclipse; (as the interval of 8 hours after an evening eclipse will generally throw the eclipse at the end of the *Saros* into the hours of night). The evening eclipse, therefore, of -584, May 28, which I adopt as being most certainly the eclipse of Thales, might be predicted from the morning eclipse of -602, May 17; and a man of astronomical and geometrical knowledge might, from the circumstances of one, form a shrewd guess on the circumstances of the other, provided the hours of day were such as to make both eclipses visible. Now the hours were such as to make both eclipses visible; and moreover, the eclipse of -602 was a large eclipse in Asia Minor and the Levant. It is, therefore, very probable that the eclipse of -584 was predicted, as is asserted. No other of the eclipses discussed by Baily and Oltmanns presents the same facility for prediction.

March 27, 1858.

Notice of some recent Modifications and Improvements in Telescopes at Paris. By R. C. Carrington, Esq.

In a recent number of the *Monthly Notices* I took occasion to mention very briefly a helioscope of new construction, by Colonel Porro, of No. 10 Boulevard D'Enfer, Paris, a partial description of which, with some satisfactory results, had previously reached me by private correspondence. Since the last meeting of the Society, having made a short visit to Paris, I have had an opportunity of examining one of these instruments more

closely, and am now able to give a somewhat more accurate description of its arrangement.

Before doing so, however, I ought, in justice to our distinguished countryman, Sir John Herschel, to mention, what I then omitted, that the essential peculiarity of construction of this helioscope was some years since proposed by him in his *Results of Observations at the Cape of Good Hope*, as may be seen at page 436 of that valuable work,—namely, the substitution of a glass for a metal speculum. It does not thereby follow of course that the same idea did not present itself independently to Colonel Porro; and I have reason to believe that M. Porro was in fact only acquainted with this proposal after successfully applying it in practice himself.

In M. Porro's instrument, the anterior surface of the disk of glass, intended for the speculum, is alone figured and polished, the posterior surface being left plane and rough as received from the foundry. The cone of rays on their way to focus is received on a plane glass reflector at the angle of complete polarization, and the reflected cone again received on a second plane glass reflector at the same angle, capable, with the eye-piece, of being turned round the axis of the cone of light as reflected from the first plane surface. The light and heat reflected from the glass speculum are not more than about $2\frac{1}{2}$ per cent of the amount received, and the orientation of the second plane reflector provides the means, on known optical principles, of further reducing the intensity of the image at pleasure. The instrument which M. Porro was so good as to put up for my inspection was of about 8 English inches aperture, and I can testify to its perfect efficiency in reducing the intensity of the image to any desired amount. The surface of the sun was seen of exquisite softness and purity of colour; but the state of the air on the day of my visit was too unfavourable for me to form any decided opinion on the definition obtained, and consequently of the power applicable for physical scrutiny. There is one great advantage in the necessity of figuring only one instead of four spherical surfaces, (as in an achromatic refractor,) which greatly reduces the labour required, and the conditions to be satisfied in obtaining a satisfactory result. There is another equally obvious, that, excepting in one particular, the quality of the glass is of much less importance. The particular referred to is this, that the disk must not exhibit the property of unequal expansion in different directions, for variations of temperature, a peculiarity often found by the artist to exist in specimens of admirable purity and uniformity in other respects.

I have no doubt that this helioscope of M. Porro will be extensively used for the purpose for which it is designed; and I will only repeat that his price for such an instrument, with its wooden tube and three eye-pieces, is one-fourth of the price of an achromatic lens of the same aperture unmounted.

On the same occasion I had an opportunity of acquainting myself with the details of a zenith telescope, of original concep-

tion in many respects, by the same artist; but not having had occasion actually to handle or try practical conclusions with it, I prefer to confine myself to calling attention to a paper on its theory which will shortly appear from the pen of my friend M. Villarçeau. (See also *Astron. Nach.* No. 1133.)

At the factory of Messrs. Lerebours and Secretan, Boulevard Faubourg St. Jacques, I saw for the first time specimens of the silvered glass mirrors of M. Foucault, which claim the consideration of observers. The highly reflective property of pure silver is well known, together with the practical difficulties which have prevented its use in an unalloyed state for the specula of reflecting telescopes. The progress of practical chemistry has, however, of late provided the means of depositing a thin coating of pure silver on the surface of glass; and at the above-named factory specula are now constructed with success for Newtonian telescopes, at little cost comparatively, of disks of glass, worked to figure on one side, coated with a layer of pure silver, afterwards polished without injury on the anterior surface. An equatoreal thus provided with a reflector of about 11 inches aperture is about to be erected at the Imperial Observatory.

In conversation with M. Secretan, I found that he had the same prejudice against the diamond as a cutting tool in dividing which I have met elsewhere. The fault commonly alleged against it is, that the point is liable to fracture in the progress of work, and give a double stroke; leading to the preference of a steel cutter, in spite of the comparative coarseness of the result. In recently constructed circles of the best workmanship, of diameters ranging from three to six feet, divided with a steel tool, I have generally found the divisions to vary from six to ten seconds of arc in width; and I cannot but regard this degree of coarseness as undesirable when the precision of measurement with the micrometer aimed at is borne in mind. Having seen in the hands of Mr. Adolph Repsold a diamond tool which had been in constant use for upwards of ten years in an unimpaired state, and results of the most exquisite fineness produced by it, I cannot but think that a careful selection of a gem is all that is required to remove the objection entertained against it, and which I think acts prejudicially to the interests of the observer. The objection to a coarse division is greatest when the bisection is made by a cross of wires in the web of the microscope; and is less when that web consists of two parallel wires of as nearly as possible the same dimensions as the division.

On a Method of very approximately representing the Projection of a Great Circle upon Mercator's Chart. By G. B. Airy, Esq., Astronomer Royal.

In the course of discussions at the Scientific Office of the Board of Trade, as to the facilities which could be given to navi-

gators for laying down very approximately on Mercator's Chart the projection of a great circle, it was suggested (I believe by Captain Geerken, of the Dutch mercantile marine), that possibly an arc of a circle, to be swept with an ordinary pair of compasses, might satisfy all wants. Acting on this suggestion, I have investigated the rule for defining the centre of the sweep ; and the result is embodied in the following simple precepts :—

1. Join the first and last points of the course (or the point of departure and the point of arrival) by a straight line : find its middle : erect there a perpendicular to that line, on the side next the equator ; and produce it, if necessary, beyond the equator. The centre of the sweep will be on this perpendicular.

2. With middle latitude, enter the following table, and take out the corresponding parallel. (It will be remarked that the four first numbers and the last can never come into use.)

Middle Latitude.	Corresponding Parallel.	Middle Latitude.	Corresponding Parallel.
°	° ′ ″	°	° ′
5	89 59 55	48	21 42
10	89 34	50	Opposite Name 16 39
15	86 52	52	11 33
20	81 13	54	6 24
22	78 16	56	1 13
24	74 59	58	4 0
26	71 26	60	9 15
28	67 38	62	14 32
30	63 37	64	19 50
32	59 25	66	25 9
34	55 5	68	30 30
36	50 36	70	35 52
38	46 0	72	41 14
40	41 18	74	46 37
42	36 31	76	52 1
44	31 38	78	57 25
46	26 42	80	62 51
		85	76 25

Opposite Name (89° 59′ 55″ – 26° 42′)

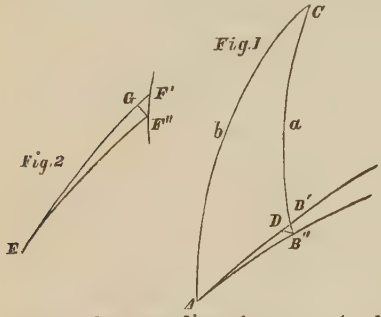
Same Name (4° 0′ – 76° 25′)

3. The centre of the sweep will be the intersection of the perpendicular, (drawn in conformity with the precept in article 1) with the parallel thus found.

4. Fix one point of the compasses in this intersection, and with the other point sweep through the point of departure and the point of arrival ; this sweep is the curve required.

The following demonstration of these rules may be acceptable to the Royal Astronomical Society.

The first part of the investigation will be directed to the following object: Upon the surface of a sphere, two curves proceed from a given point in the same direction, one being the loxodromic curve (or that which, on Mercator's Chart, will be represented by a straight line), the other being an arc of great circle; to find the distance between the intersections of these two curves with a meridian at a limited difference of longitude, as measured upon that meridian.



In Fig. 1 let C be the pole, A the given point from which the curves proceed in the same direction (the angle at A being the same for both), $A\,B'$ the loxodromic curve, $A\,B''$ the arc of great circle; also use the letter C for the angle C, or difference of longitude of meridians; A for the angle A, or azimuth common to the two directions at A; b for the colatitude of A. The letter a' may be used for $C\,B'$ in the first investigation, and a'' for $C\,B''$ in the second.

First, for the Loxodromic Curve.

The characteristic of this curve is given by the equation $\delta\, a' = -\sin a'.\ \delta\, C \times \cot A$; therefore $\frac{d\,a'}{d\,C} = -\cot A\,.\sin a'$; and $\frac{d^2 a'}{d\,C^2} = -\cot A\,.\frac{(d \sin a')}{d\,C} = -\cot A\,.\cos a'.\ \frac{d\,a'}{d\,C}$

$$= +\cot^2 A\,.\sin a'.\cos a'.$$

In order to apply Maclaurin's theorem to the expansion of a' in powers of C, we must give to a' its value when $C = 0$, that is, we must put b for a'.

Thus we find

$$C\,B' = b - \cot A\,.\sin b\,.\,C + \cot^2 A\,.\sin b\,.\cos b\,.\,\frac{C^2}{2} + \&c.$$

Second, for the Arc of Great Circle.

In the spherical triangle,

$$\cot A\,.\sin C = \cot a''.\sin b - \cos C\,.\cos b.$$

Differentiating this equation twice, a'' and C being the only variables,

$$\cot A \,.\, \cos C = \frac{-\sin b}{\sin^2 a''} \,.\, \frac{d\,a''}{d\,C} + \sin C \,.\, \cos b$$

$$-\cot A \,.\, \sin C = \frac{2 \sin b \,.\, \cos a''}{\sin^3 a''} \,.\, \left(\frac{d\,a''}{d\,C}\right)^2 - \frac{\sin b}{\sin^2 a''} \,.\, \frac{d^2 a''}{d\,C^2} + \cos C \,.\, \cos b.$$

For the application of Maclaurin's theorem, put $C = 0$, $a'' = b$, then

$$\frac{d\,a''}{d\,C} \text{ becomes } = -\cot A \,.\, \sin b$$

$$\frac{d^2\,a''}{d\,C^2} \text{ becomes } = \frac{2 \cos b}{\sin b} (\cot A \,.\, \sin b)^2 + \sin b \,.\, \cos b$$

$$= \sin b \,.\, \cos b \,(1 + 2 \cot^2 A)$$

And

$$C B'' = b - \cot A \,.\, \sin b \,.\, C + (1 + 2 \cot^2 A) \,.\, \sin b \,.\, \cos b \,.\, \frac{C^2}{2} + \&c.$$

Taking the difference between $C B'$ and $C B''$, $B' B'' = \operatorname{cosec}^2 A \cdot \sin b \,.\, \cos b \,.\, \frac{C^2}{2} + \&c.$ When the angle C is not immoderately large, the term

$$\operatorname{cosec}^2 A \,.\, \sin b \,.\, \cos b \,.\, \frac{C^2}{2}$$

will represent with abundant accuracy (and with perfect accuracy to the second order) the distance $B' B''$.

From B'' draw the perpendicular $B'' D$ upon $A B'$. Then $B'' D = B' B'' \times \sin B'$; and when C is not large, the angle B' will not sensibly differ from the supplement of A; and $B'' D = B' B'' \times \sin A =$

$$\operatorname{cosec} A \,.\, \sin b \,.\, \cos b \,.\, \frac{C^2}{2}.$$

Also $A B'$ or $A B''$ is sensibly equal to

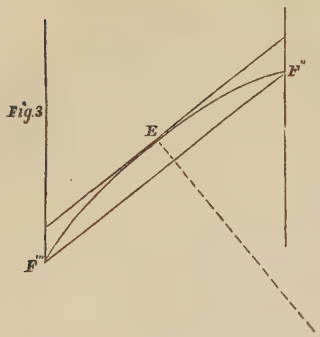
$$\operatorname{cosec} A \,.\, \sin b \,.\, C.$$

Now, let E, F', F'', G, in Fig. 2 represent the projections of A, B', B'', D, upon a Mercator's Chart whose equatoreal radius is the same as that of the sphere. Then $E F'$ becomes a straight line; and the lengths of the several lines will be found from those in the first diagram by multiplying them by cosec b.
Thus

$$E F'' = \operatorname{cosec} A \,.\, \sin b \,.\, C \times \operatorname{cosec} b = \operatorname{cosec} A \times C;$$

$$F'' G = \operatorname{cosec} A \,.\, \sin b \,.\, \cos b \,.\, \frac{C^2}{2} \times \operatorname{cosec} b = \operatorname{cosec} A \,.\, \cos b \,.\, \frac{C^2}{2}.$$

The radius of the sweep which will touch the straight line $E F$ at E, and will pass through F'', will be $\frac{(E F'')^2}{2 F'' G}$. Substituting the values above, the radius of the sweep $=$ cosec A . sec b.



From the neglect of succeeding terms in the series employed, it is possible that the sweep thus obtained may be a little too sharp for the arc EF''; but if so, it will be a little too flat for the arc EF''', (Fig. 3), or *vice versâ*. Hence it will represent the curve as a whole with great accuracy. The elements are to be taken for E, whose latitude does not sensibly differ from the middle latitude. Instead of b, therefore, we must use $90° -$ middle latitude ; and thus we get

Radius of the sweep = cosec A . cosec middle latitude.

Suppose this radius laid down, in the direction of the dotted line in Fig. 3. This dotted line will make with the meridian an angle $= 90° - A$. Consequently its extremity will fall on a parallel whose distance from parallel of E, or of middle latitude,

$$= \text{cosec. } A \times \text{cosec middle latitude} \times \sin A$$
$$= \text{cosec. middle latitude.}$$

In order to find the numeration of the parallel on which this distance will fall, we must refer to the theory of Mercator's Chart. Now in Mercator's Chart, the distance of any parallel from the equator = Naperian log tan ($\frac{1}{2}$ latitude + 45°), the unit of measure always being the equatoreal radius of the chart. Let then x be the latitude of the parallel on which the distance falls (if on the same side of the equator), or y the latitude of the parallel (if on the opposite side of the equator).

Then we must have

$$\text{Nap. log tan } \left(\frac{\text{middle latitude}}{2} + 45°\right) - \text{Nap. log tan } \left(\frac{x}{2} + 45°\right)$$
$$= \text{nat. cosec. middle latitude.}$$

or

$$\text{Nap. log tan } \left(\frac{\text{middle latitude}}{2} + 45°\right) + \text{Nap. log tan } \left(\frac{y}{2} + 45°\right)$$
$$= \text{nat. cosec. middle latitude}$$

Multiply the equations by 0·43429448, the modulus of common logarithms ; then

$$\log \tan \left(\frac{x}{2} + 45°\right) = \log \tan \left(\frac{\text{middle latitude}}{2} + 45°\right)$$
$$- 0{\cdot}43429448 \times \text{nat. cosec. middle latitude}$$

or

$$\log\tan\left(\frac{y}{2}+45^\circ\right) = 0{\cdot}43429448 \times \text{nat. cosec. middle latitude} - \log\tan\left(\frac{\text{middle latitude}}{2}+45^\circ\right)$$

the logarithms now employed being the common logarithms of ordinary tables.

By means of these formulæ, the latitudes of the "corresponding parallels" have been computed in the small table given in the beginning of this paper.

February 12, 1858.

A Memoir on the Problem of Disturbed Elliptic Motion.

By A. Cayley, Esq., F.R.S.*

"I venture to take up the problem of disturbed elliptic motion, for the sake of a further elaboration of the analytical theory. The points which present difficulty are the measurement of longitudes in the varying plane of the orbit, and (in the lunar theory) the determination of the position of the orbit, by reference to the varying plane of the sun's orbit; it is in memoirs and works on the lunar and planetary theories, often difficult to discover where or how (or whether at all) account is taken of these variations, and the analytical mode of treatment is for the most part very imperfect. I must except always Hansen's *Fundamenta Nova*, where the points referred to are treated in a perfectly rigorous manner. There is, however, a want of clearness in the form under which his investigations are presented; and the comprehension of them is greatly facilitated by Jacobi's remarks, published under the title *Auszug zweier Schreiben des Professor Jacobi an Herrn Director Hansen* (*Crelle*, t. xlii. pp. 12–31 (1851)). Jacobi observes that the integration of Hansen's system of differential equations introduces seven arbitrary constants, which, in the expressions for the co-ordinates referred to fixed axes, reduce themselves to six. The seventh constant, neglecting the disturbing forces, is, in fact, a constant, which determines the position in the orbit, of the arbitrary origin from which the longitudes in orbit are reckoned. I have, in my paper "On Hansen's Lunar Theory," *Quarterly Math. Journal*, vol. i. pp. 112–125 (1855), termed this origin "the departure point," and longitudes measured from it "departures." The seventh constant may be taken to be the departure of the node. I reproduce in the present memoir the explanation of what is meant by the departure when the plane of the orbit is variable. If the problem is treated by the method of the variation of the elements, the seventh constant becomes, like the other elements, variable; and we have thus a seventh variable element, the departure of the node. The element just referred to (the departure of the node) forms, with the longitude of the node and

* This paper will be printed *in extenso* in the forthcoming volume of *Memoirs*.

the inclination, a group of three elements, which determine the position of the orbit and of the departure point. The co-ordinates of the planet are in the first instance taken to be the radius vector, longitude, and latitude; but the before-mentioned three elements being considered as given, the position of the planet depends only on the radius vector and the departure. These may be then expressed in terms of the remaining four elements; as to the choice of these four elements, it is to be remarked that there is one element which only enters through the mean anomaly, and that there is great convenience in representing with Hansen the mean anomaly by a single letter; and that in the various formulæ we may use in the place of the element implicitly involved in the mean anomaly, the mean anomaly itself, or treat the mean anomaly as an element; the four elements may be taken to be the semi-axis major, the excentricity, the mean anomaly, and the departure of the pericentre. And joining to these the before-mentioned three elements, we have the system of elements represented in the memoir by a, e, g, ϖ, σ, θ, φ. It has been assumed so far that the three elements determine the position of the orbit and departure-point in reference to a fixed plane and origin of longitudes; but we may suppose more generally that instead of the fixed plane and origin of longitudes we have a variable plane or orbit of reference and a departure-point in this variable orbit of reference. The quantities which determine the orbit of reference and departure-point are naturally taken to be the departure of the node, longitude of the node and inclination; these are assumed to be given functions of the time, and they are in the memoir represented by σ', θ', φ'. The three elements of the planet's orbit (viz. departure of node, longitude of node, and inclination) in relation to the orbit of reference and departure-point therein, are in the memoir represented by Σ, Θ, Φ, and the system of elements ultimately adopted is therefore a, e, g, ϖ, Σ, Θ, Φ. I obtain formulæ for the variations of these elements under two different modes of expression of the disturbing function: first, when the disturbing function is expressed in terms of the radius vector and departure and of the three elements Σ, Θ, Φ; secondly, when the disturbing function is expressed in terms of the seven elements a, e, g, ϖ, Σ, Θ, Φ. The establishment of the two sets of formulæ just referred to constitutes the chief object of the memoir; but the memoir contains some other investigations and formulæ in relation to the general subject."

On certain Connecting Points between Lunar and Terrestrial Volcanoes. By Prof. C. Piazzi Smyth, F.R.S., Astronomer Royal for Scotland.

(*Substance of a Lecture delivered ot the Meeting of the Society on March 12th, 1858.*)

In a recent publication of our Society, the upper parts of Teneriffe were described as a most moon like region. The ex-

pression is not a little descriptive; and why? Because, at those elevations the air is thin and transparent; no cloud floats therein during a large part of the year; vegetation is reduced to a minimum; sharp jagged rocks rear their naked forms around, brilliantly, and even blindingly, illumined by the intense rays of an undimmed sun on one side, while they throw on the other shadows as remarkable for their darkness; and, finally, all those rocks, plains, and slopes, are thoroughly and purely volcanic.

Every astronomer will at once understand and allow the connexion, but would yet do unwisely were he to overlook the opinions of several eminent geologists who affirm, that the telescopic features made out on the lunar surface are not volcanoes at all. However positively this view is maintained in conversation, I have not yet been fortunate enough to meet in print with anything that could, with due respect to geologists of standing, be considered a full exposition of their reasons. Rather, then, than attempt to discuss opinions evidently weak and confessedly imperfect, and without entering into the extensive subject of volcanoes generally, though for their natural development and proper action, *pure et simple*, the moon might perhaps be shown to be a fitter region than the earth, I will at present merely bring forward some few facts, equally acceptable, I trust, as facts to either party, and calculated to supply, in some measure, a short link in that large gap which intervenes between the methods of observation hitherto employed on lunar and terrestrial volcanoes, real or imaginary. An immense difference of this sort must always prevail; for whereas actual eruptions, and chemical analysis of the materials erupted, are the most powerful of proofs for earthly craters, we can never hope to employ them in the moon. There are naught but extinct volcanoes, so distant from us too, that rare indeed it is to find a man who can completely realise what he sees of figure and surface with the telescope, so as to form in his mind as rational an idea of them as he does of an earthly mountain that he has actually walked over.

To approximate these respective methods of research, and in that way eliminate their peculiar sources of error, we may evidently, with much advantage, leave the active volcanoes of the earth (say Vesuvius) where the fire and fiery smoke, and devastations of the last or present eruption, force themselves too prominently on the eyes and nerves of all beholders, and turn rather to some extinct specimen, where we may contemplate the traces of successive eruptions during myriads of years, and the last of them as impassively as the first; always provided that such instance be not overlaid by any geological changes consequent on our dense and watery atmosphere, and that its features can be viewed from such heights and distances as in the naked eye to subtend something like the same angles that those of the moon do in the telescope.

Had we to search over the whole breadth of the earth for such an example, we could hardly find a better one than the colossal

Peak of Teneriffe, of which, through the liberality of the late first Lord of the Admiralty, Sir C. Wood, prompted by the Astronomer Royal, G. B. Airy, Esq., and afterwards aided by the kind contributions of many of our members, I am enabled now to lay some particulars before the Society.

First, I would request attention to the fine model, on the scale of $\frac{1}{3000}$th kindly prepared for the occasion by my friend, Mr. James Nasmyth, who, while employing upon it all that artistic skill for which he is so well known to all present, has yet conformed most faithfully and conscientiously to all the measurement particulars of length, breadth, and height, that I could furnish him with.

The space thus represented is about 16 miles square, and embraces part of the northern coast line of the Island of Teneriffe, together with the Peak, the great crater, and all the most elevated parts of the interior.

The colouring is according to nature; the green near the sea-level representing the vegetation, abundant at and below the summer cloud-level, or 4000 feet; above that line the hues of lava rock predominate; the oldest, light and bright-yellow, are the most extensive; the latest, black, are chiefly confined to the upper part of the Peak, and to some special crater mouths in other parts; while the intermediate are red and brown.

By throwing a strong ray of side light on the model,* the variations of form may be brought out prominently; and amongst them the huge size of the "elevation crater" is most remarkable, being somewhat more than 8 miles in diameter. It is on the floor of this crater that has been formed the central cone, known as the Peak of Teneriffe. From the brink of the southern wall of the great crater, 8900 feet above the sea, and 2000 feet above the crater-floor; and again, from a station on the flanks of the central cone, at an elevation of 10,700 feet, excellent birds-eye views were obtained, during the two months we spent there, over features of the volcanic landscape; which then, seen in the thin transparent air above the clouds, and under a vehement solar illumination, assumed very much indeed of a lunar look.

Rather than trust myself to the possibility of having introduced any theoretical ideas into my own drawings of these views, I will beg to exhibit, by aid of a Drummond light and optical apparatus, a series of 18 photographs, taken on the brink of the great crater, and as many more on the slopes and at the summit of the central cone.

From these series may be gathered, with reference to A, the figure of the great crater,

* This was done at the lecture by means of a Drummond lime ball light, which was afterwards employed in magnifying and exhibiting, by optical pictures, a series of thirty-six photographs of volcanic features, at from 7,000 to 12,200 feet above the sea-level. Mr. Nasmyth had also very kindly allowed six of his large and unequalled drawings of the moon's surface to be suspended in the room, for the purpose of contrast and comparison.

1st. The greater steepness of the internal to the external surface of the crater-wall; the inside being near its summit 80° and 90°, while the outside is but 12° to 14°;

2d. Proofs of extensive fracture and subsidence of not only the area of the crater, but of some portions of its flanks;

3d. The stratification of the material of the walls nearly conformable with the outward slope of the crater, in every direction, towards the sea.

With reference to B, the figure of minor craters,

1st. The large proportion frequently found of breadth to height, making them look, when viewed from above, more like bowls or saucers than the usual ideal of terrestrial volcanoes, *i. e.* a high cinder cone with a small hole at the top. One of the minor craters in the floor of the great one, on its southern side, is altogether a hole; and even the heaps of rapelli thrown up from it do not seem to rise above the neighbouring surface;

2d. The general greater steepness of the walls towards the interior;

3d. The preponderance, but not the universality, of a break in the walls, and that break on the seaward side, and generally the place of escape of a lava stream.

With reference to C, the central cone,

1st. Greater steepness of angle of ascent than shown by the environing crater;

2d. Looseness of materials; for whether pumice or lava, the blocks, large or small, seemed perfectly loose and separate, like so much sand in an hour-glass of large size;

3d. Extreme whiteness of interior of terminal crater;

4th. A tendency to, if not a formation of, triplicity in the central cone. The central head, Rambleta, after exuding much lava from a terminal crater about three-fourths of a mile in diameter, has had it since filled up, and had a small cone formed on it, the present culminating point of Teneriffe.

The western head, Chajorra, seems to have had its crater, of the same size as Rambleta, once filled up with fluid lava level with the brim; to have cooled in this state, and then to have broken up and ejected most of this filling material except a portion adhering to the southern wall.

The eastern head, Montaña Blanca, is a dome-shaped mass of pumice, with several lava streams exuding through it.

With reference to D, the flow of lava streams,

1st. That the lavas of the great crater flowed under water, hence their stratification, their density, and the absence of pumice;

2d. That the lavas of the central cone were subaerial;

3d. That of these, the yellow are, by their position, the oldest; the red coming next, and the black last;

4th. That the colours confirm the same order, the yellow and red being mere surface oxidations;

5th. That the yellow was the most abundant in volume, and flowed easily, and the black least so;

6th. That the dynamics of their flowing still remain most visible and most instructive: the yellow predominating in transverse waves, like those of the sea surf; the red having the same transverse waves, though in a less degree, are looking more like glacier wrinkles, and accompanied with some longitudinal markings; while the black have only the longitudinal markings, and look, in fact, like mere long ridges of dry pulverulent matter.

In comparing these features with lunar volcanoes, the first remark may be, that our great crater, eight miles in diameter, is still nothing to compare with many in the moon, some fifty or sixty miles in diameter.

Are those great lunar circles, then, therefore not craters?

To this end we may answer:—

1st. That the frequency with which small craters break through the walls of large ones in the moon, and never large through small, indicates that the earlier volcanoes there were, on the whole, always the larger; and this practical result is quite agreeable to the theory of volcanic action, which ascribes its leading features to the remains of heat due to the mode of planetary formation.

2d. That so far as Teneriffe is concerned, the large volcano was the earlier, as, too, it should be according to the theory just mentioned, which is equally applicable to the earth as to the moon.

The distance, however, which we can go back in the volcanic history of the earth is as nothing compared to its actual age, or compared to what we can in the moon, for this very simple and patent fact, the presence of an ocean on the earth combined with secular variations of land and sea surface.

These variations, which are still going on, have been in force for such immense periods of time that geologists have found no part of the earth whatever, save new volcanoes recently thrown up, which has not been more than once beneath the ocean, so long and at such a depth, as to have sedimentary strata thrown down upon it to a depth of many thousands of feet. There is no part of the world, not even the giant chain of the Andes, which seems to have escaped this submersion and precipitation.

What, then, can have been the fate of the earlier and more powerful volcanoes of our globe, than in their turn to have sunk under the sea, and had all their irregularities first rasped and removed by the destructive actions of ages of surf and waves gradually creeping over them, and then having them covered under such depths of strata of hard rock, that when once more lifted up into the atmosphere no quarrying by man can ever expose their full proportions.

When we go back from Chajorra or Rambleta, at present unextinct and some $\frac{3}{4}$ of a mile in diameter, to the great crater of Teneriffe, 8 miles in diameter, and extinct during the human period; or equally from Vesuvius, at present active, and $\frac{1}{4}$ of a mile in diameter, to Somma, 2 miles in diameter, and perfectly

quiet ever since Italy has been dry land, we find the older craters to have been the larger; and if they are not very large as compared with those of the moon, it is because their age is, after all, quite in the modern times of Geology, and as shown by the shells found in the lower slopes of either volcano to belong to the post-pliocene period.

The grand volcanic circles, then, of the older "primary" and "secondary" days can never be seen by man; but would he form some idea of their mighty proportions, when the crust of the earth was thin, its whole interior fluid with heat, and its more volatile materials going off in oceans of vapour, agitating the whole globe, and reacting against the weak exterior with terrific violence, let him look to the surface, our surface, of the moon, never yet depressed under an ocean, and there, as in a glass, held up to us for our instruction, may be seen what must have been the throes endured by the earth, and what the size of volcanic mouths in its early history of fiery ordeal.

Many further differences may be found on close observation between lunar and terrestrial volcanoes, as dependent on the infinitesimal atmosphere around the former, and the smaller force of gravity acting on them. To assist in investigating the nature of such modifications, we have, happily, in Teneriffe, specimens of volcanoes which at the time of their activity were some of them sub-marine, and some sub-aerial; and when we look to the smooth slopes of the former, some 12°, increasing to 28° in the latter, with extreme roughness of surface, we can hardly but allow that this is a strong approach to the still steeper and more jagged forms in the moon.

In short, with its rare atmosphere (22 mercurial inches), so dry that the rocks do not disintegrate, vegetation does not spread, and a slow change of colour is all that marks the lapse of successive centuries, the little volcanic world of the great crater of Teneriffe, raised high above the clouds, is a most important region to be studied and mapped with reference to lunar investigations.

To map this region correctly would be a work of years; and all that I have done is to point out the character of the phenomena visible from two points of the circle—viz., the stations established on Guajara and Alta Vista.

The terrestrial part of the problem is thus still only begun, and the greater part remains still to do; while the astronomical portion, or the telescopic part, will have more and more work prepared for it, as often as any characteristics of form are made out by theory or earthly analogy, as necessary to volcanic action.

Amongst them may be already placed the dynamic waves and wrinkles of lava-streams already mentioned; and though no telescope has yet seen them, nor perhaps can expect to do so, unless mounted up on such a peak as that of Teneriffe, high above the clouds and the tremors of the atmosphere, yet the security which the discovery of such a fact would give to investigations

into the moon's physical history, might render the attempt well worthy of attention.

[When Professor Smyth had concluded his lecture, Mr. Nasmyth, at the request of the Astronomer Royal, gave an interesting exposition of his views on various points relative to the physical constitution of the moon, which he was enabled to illustrate by means of several of his admirable delineations of the moon's surface exhibited at the meeting.—Editor.]

Eclipse of the Sun, Sept. 17–18, 1857.

On the occasion of the occurrence of this eclipse, which was visible in India and China, Captain Shadwell, R.N., now on active service in the Chinese Sea, with praiseworthy zeal circulated a notice of the prediction of the eclipse at various places in hopes that observations of the phenomenon might be duly made, if circumstances proved otherwise favourable. The eclipse was accordingly observed at a few places, and the results, including his own observations, are contained in the following communication from Captain Shadwell.

Observations in China.

I. Clarke Point, Hamilton Creek, Canton River.

Lat. 23° 2′ N.

Long. $7^h\ 23^m\ 12^s$ E.

Observer, Capt. Shadwell, H.M.S. Highflyer.

Approximate time of beginning Sept. 17th, $23^h\ 41^m\ 56^s$

,, ,, ending Sept. 18th, $2^h\ 29^m\ 58^s{\cdot}5$.

The moments of first contact not accurately noted, probably several seconds in error. The last contact accurately obtained.

II. Wellington Battery, Hong Kong.

Lat. 22° 16′ N.

Long. $7^h\ 36^m\ 36^s$ E.

Observer, Capt. Bate, H.M.S. Actæon.

Ending of the eclipse Sept. 18th, $2^h\ 35^m\ 29^s{\cdot}5$, good observation.

III. Ningpo.

Lat. 29° 52′·5 N.

Long. $8^h\ 6^m\ 12^s$ E.

Observer, Mr. C. Fox, H.M.S. Hornet.

Beginning Sept. 18th, $0^h\ 40^m\ 46^s$

Ending ,, $2^h\ 39^m\ 56^s$

IV. Shanghai.

Lat. 31° 15′ N.

Long. $8^h\ 5^m\ 56^s$ E.

Observer, Capt. Sir F. Nicholson, H.M.S. Pique.

Approximate time of beginning Sept 18th, $0^h\ 38^m\ 0^s$

" " ending, " $2^h\ 35^m\ 28^s$

All the above times are expressed in mean time at the respective places.

A delineation of a remarkable spot recently observed on the sun's disk by Mr. Hodgson, and two drawings of *Jupiter* by Capt. Jacob, were exhibited at the meeting.

The Annular Solar Eclipse of March 14–15.

The weather proved generally unfavourable in England for the observation of this eclipse, and it would appear from the *Astronomische Nachrichten*, that our friends in the north of Europe have not been more fortunate. Several communications have been received containing more or less complete accounts of the phenomenon, a *résumé* of which will be inserted in the impression of this periodical for April.

Notices of several publications are in type, but they have been unavoidably postponed to next month for want of space.

Mr. Cayley sends the following erratum in Professor Hansen's *Fundamenta Nova* :—

Page 174, the co-efficient of e^3 in $Q_s^{(1)}$ should be $\frac{23}{24}$ instead of $\frac{33}{24}$.

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